

CONTRIBUTION TO OPTIMIZATION OF ORGANIZATION AND CONTROL OF PAY TOLL SYSTEMS ON MOTORWAYS

The paper addresses some essential problems in the optimization of paytoll system control and organization on a single motorway or in a motorway network. These problems have hardly been treated in the literature, either from the standpoint of the usage of today's optimization methods or with respect to the fact that optimization tasks immanently involve uncertainty as an element of a decision making process.

A historical background of toll collection problem is presented at the beginning. Much older than commonly thought, toll collection dates back to ancient times and has ever since been present worldwide. Toll collection on motorways is of a more recent date and originates from the beginning of the last century.

In this paper multicriteria methods have been applied to solving two basic issues relating to motorway paytoll systems: the choice of an optimal paytoll system structure and the choice of an optimal level of technical support to these systems. Both problems are solved in the presence of uncertainty that is immanent in either the weights of criteria used in a multicriteria ranking procedure or the values of a certain number of criteria that cannot be determined in a unique way. This uncertainty is treated using the theory of fuzzy sets and fuzzy logic. A new algorithm for the comparison of linguistically expressed fuzzy variables is given and the results obtained by this new method are compared with those obtained by methods known from the literature. The following paytoll system structures have been compared for the purpose of selecting the best one: an open, a semi closed and closed system, system with vignette and a fiscal system – special taxes. After that, seven different levels of technical support to paytoll systems, ranging from a basic one to today's highly advanced systems relying on GPS and RF technologies, have been compared. The complete methodology has been applied to the example of Belgrade – Hungarian border motorway.

The second paytoll system control and organization problem treated in this paper is the choice of an optimal location of a logistic center for paytoll system equipment maintenance. A motorway network is modeled as a weighted graph and the problem of logistic center location is solved by finding the center and median of this graph. Graph weight factors are taken to be quantities determined in the presence of uncertainty and they are treated in the paper as fuzzy quantities describing the importance of graph nodes and the lengths of graph links. To improve precision, new definitions of a fuzzy center and fuzzy median are introduced and four new algorithms for determining them are given. The most attractive among them is the algorithm for multicriteria determination of a fuzzy center and median of a graph, which is presented in the literature for the first time in this form. The obtained theoretical results have been tested using the example of determining the location of a logistic center for Belgrade – Hungarian border motorway.

The third problem considered in the paper involves the policy of paytoll system spares inventory control. Two issues are addressed: (1) spares demand forecasting and (2) replenishment policy. Having in mind the complexity and spatial distribution of a paytoll system, uncertainty in the demand for spare parts is described by linguistic, fuzzy variables. Out of a set of selected inventory replenishment policies, the best one has been determined by applying the SIMEX simulation apparatus. The application of the complete procedure is illustrated using some basic parts of a paytoll system.

The fourth problem treated in the paper is management efficiency measurement. This problem has been stated as a multicriteria task solved in a fuzzy environment, i.e., all the

objectives (or criteria) with respect to which efficiency is measured are not quantities whose value is expressed only numerically, the value of some of them is expressed linguistically.

The paper concludes by discussing the results obtained and indicating future research directions in relevant fields.